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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 10 June 2002 with an application for Letters Patent number 519464 made by RADIAN TECHNOLOGY LIMITED.

Dated 30 May 2003.

Neville Harris
Commissioner of Patents

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519464

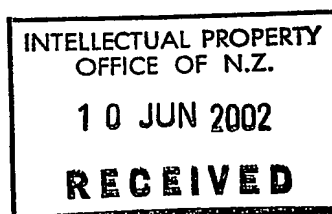A MEASUREMENT AND MONITORING SYSTEM

We, **RADIAN TECHNOLOGY LIMITED**, a New Zealand company, of 1
Coolidge Street, Brooklyn, Wellington New Zealand do hereby declare this
invention to be described in the following statement:

PTO409960

A MEASUREMENT AND MONITORING SYSTEM

FIELD OF INVENTION

This invention relates to in-line measurements for quality

5   control and management of dairy stock and plant.

BACKGROUND

Approaches in the field can be divided into systems for

mastitis detection and systems for volume yield.

10

Elevated ion levels in the harvested milk that result in an

increase in solution conductivity is symptomatic of mastitis.

Measurement of conductivity has formed the basis for many

mastitis detection systems but practical issues have detracted

15   from useful deployment in a farm context.

A common method to measure conductivity is by positioning

electrodes in the solution through the wall of a containing

vessel.

20

A simple implementation of this approach is a hand held

conductivity meter. This requires sample collection by the

manual stripping of milk directly from the cow. This is

resisted by the cow and becomes a time consuming process poorly suited to high production milking.

Improvements have been proposed by incorporating electrodes
5   directly into the claw of the milking apparatus. This has the potential of facilitating automatic in-line detection with improved reliability using individual quarter conductivity measurements for comparative analysis. Obviously this approach dictates the use of a specialist claw which is generally
10   larger than the traditional arrangement. Both the lack of flexibility in choice of claw and the size are undesirable. In addition, wiring for power and sensor location on the harsh parlour floor environment and around animal hooves represents practical reliability issues due to incidents of breakage,
15   water damage or wiring failure.

Some conductivity measuring systems have been placed at the top of the long milk hose above the parlour floor. These systems have been targeted at detecting the presence or
20   absence of solution to determine when a cow is finished milking. Accurate measurement for the purposes of mastitis detection has not yet been made practical with this approach.

All approaches with electrodes in solution are subject to
electrode fouling or poisoning. This is due to the build up of
coatings with poor solubility, preferential plating of metal
ions over time or the effect of cleaning agents used in the
milking process. The result is calibration drift and
measurement inaccuracy that can only be rectified with time
consuming regular maintenance or replacement.

To overcome the difficulties associated with electrodes in
direct contact with solution, some systems have been proposed
with sensing arrangements on the outside of a plastic wall
containing the solution. Such arrangements necessarily use
high frequency fields since plastic blocks direct or low
frequency fields. In proposals to date that use fields of this
type, both the effect of the containment wall and the
dielectric behaviour of the solution dominate any measurement
result and overshadow any small effect due to solution
conductivity. As a consequence, while sensing through a
plastic containment wall is adequate in detecting the presence
or absence of solution, it has not been able to measure
conductivity to the accuracy required for mastitis detection
in the practical milking situation.

A compounding issue for automatic in-line sensing is the mixed air and solution nature of the flow. The presence of uncertain amounts of air in the solution results in uncertainty in bulk measurements such as conductivity. Systems have been proposed

5 that employ mechanical sampling arrangements that allow for the solution to settle as discrete samples. These systems are complex and often involve moving parts that reduce reliability and increase cost. Many automatic sampling arrangements also require regular cleaning to ensure hygiene levels are

10 maintained.

Approaches for in-line measurement of volume yield also depend on separating solution from air. With most arrangements separated solution is accumulated in a sampling reservoir. One

15 arrangement uses a large reservoir that samples a known proportion of solution by splitting a solution jet stream. Yield is determined from total sample volume and the sample is either returned to the bulk solution or discarded. Other proposals involve counting of smaller reservoir samples as

20 they continuously fill and are emptied. In both cases manual and automatic variations have been suggested.

As with comparable sampling systems for conductivity measurement, arrangements for yield measurement are complex

and often involve moving parts that reduce reliability and increase cost. Here again they require regular cleaning to ensure hygiene levels are maintained.

5   Solutions integrated into management information systems have also been proposed. These systems typically include information in addition to conductivity and yield. They involve data bases and provide for the manipulation of management information through computer workstations. The use

10   of data bases allows for the tracking of long term trends which has the potential to improve the reliability of measurements and provide information for comparison overtime or between stock within a particular farm. However, systems of this type are expensive and are necessarily dependent on the

15   underlying sensor technology with the accompanying difficulties described herein.

No cost effective solutions are proposed at this time that are suited to automatic performance management within farm norms

20   during the normal milking process.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by example with reference to the accompanying drawings in which:

5 Figure 1   shows a schematic diagram of a manifold assembly;

Figure 2   shows a cross-sectional side view of a manifold assembly;

Figure 2a shows a top view of the manifold assembly of Figure 2;

10 Figure 3   shows a schematic diagram of a sensing system;

Figures 4a and 4b show phasor diagrams produced by the circuit of Figure 3;

Figure 5   shows a sensor circuit for use in the system of Figure 3;

15 Figure 6   shows a schematic diagram of a signal conditioning circuit; and

Figure 7   shows an information flow diagram.

DISCLOSURE OF INVENTION

20 In an effort to ameliorate the forgoing disadvantages or to at least provide the public with a useful choice, the present invention proposes methods and apparatus of use in monitoring and determining stock and plant performance during the normal milking session.

According to the first aspect of the invention there is provided a method for conductivity measurement comprising the steps of:

5   dividing a fluid or mixed gas and fluid flow between a first and second flow path;

causing the fluid to flow preferentially within the first path having a relatively long and narrow form;

measuring a parameter determined by the fluid in the path

10   having a relatively long and narrow form;

determining the conductivity of the fluid based upon the measured parameter.

According to the second aspect of the invention there is

15   provided a conductivity measurement apparatus comprising:

a manifold including a first and second flow path for conveying a fluid or mixed gas and fluid flow, causing the fluid to flow preferentially within the first path of relatively long and narrow form;

20   a sensor provided for the first path for measuring a parameter determined by the fluid;

a conductivity determining circuit which determines the conductivity of the fluid based upon the parameter measured by the sensor.

According to the third aspect of the invention there is provided a method for measurement of conductivity comprising the steps of:

5   measuring a parameter determined by a fluid by sensing through a containment wall made of electrically insulating material;

improving the measurement sensitivity by at least partially cancelling the effect of the dielectric properties

10   of the containment wall;

providing an output representing the conductive component of the measurement.

According to a fourth aspect of the invention there is

15   provided an apparatus for measuring conductivity comprising:

a sensor arrangement for measuring a parameter determined by a fluid through a containment wall made of an electrically insulating material;

a signal conditioning circuit that converts the measured

20   parameter into an electrical form;

a signal conditioning circuit that improves the measurement sensitivity by at least partially cancelling the undesirable effect of the dielectric properties of the containment wall;

a signalling conditioning circuit that provides an output that represents conductivity.

According to the fifth aspect of this invention there is

5 provided a method for determining dairy stock and plant performance comprising the steps of:

making performance measurements during a normal milking session;

collecting measurements to incrementally develop

10 performance profiles during a normal milking session;

storing performance profiles as a completed set at the end of a normal milking session

performing a best fit matching of a stored set to the current milking;

15 providing settings for user or pre-determined standards of performance;

providing performance assessment for measurements during the current milking session using assessment criteria that are in part determined by stored profiles.

20

According to the sixth aspect of this invention there is provided an apparatus for determining dairy stock and plant performance comprising:

a unit for making measurements during a normal milking session;

a unit for collecting and developing measurement profiles, storing completed sets of profiles, matching stored
5   profiles to the current milking and calculating performance criteria to be compared with measurements during the current milking session from standards of performance;

a unit for annunciation of performance during the current milking session;
10   a network for communicating information between units.

DETAILED DESCRIPTION

The present invention consists of methods and apparatus of use in the monitoring and determination of stock or plant
15   performance during the normal milking process. The methods and apparatus may be used independently or used in combination.

In one embodiment of the present invention the use of the combined methods and apparatus the results in a system that
20   monitors and determines alerts for abnormal stock performance including indicators of milk with mastitis, milk flow, milk volume yield and end of milking. It also monitors and determines alerts for abnormal plant performance including abnormal bail equipment operation and cleaning

characteristics. In this embodiment of the present invention, the system comprises a Bail Unit for each milking cluster and a single central Command Unit. A common 2-wire bus for power distribution and communication connects all units.

5

Of relevance to the first and second aspects of the present invention is a manifold that connects in series with the long milking tube from the milking cluster. Solution is transported in the milking tube under differential vacuum and subsequently

10   flows through the manifold as shown in Figure 1.

Solution enters the manifold through the entry pipe (1) and passes into an entry chamber (2). Air and solution are separated in the entry chamber by a whirlpool effect with

15   solution outflow from the outer peripheral of the rotating mass and/or a surge reservoir with solution outflow from the bottom of the reservoir.

From the entry chamber outflow the separated solution passes

20   into an accumulation chamber (3) within which the solution is able to build-up and provide short periods of continuous supply to an attached conductivity tube (6).

The conductivity tube defines the physical arrangement for conductivity sensing. It has a high length to sectional area ratio and a co-ordinated external electrode configuration (12) that enhances solution conductivity effects and reduces

5   solution dielectric effects. This allows for the extraction of a useful conductivity measurement from the otherwise dominating solution capacitance. In one embodiment of the present invention useful performance was achieved with a plastic tube of about length 100 mm, diameter 9 mm, and wall

10   thickness 0.9 mm and electrodes of about 25 mm length encircling each end of the tube.

The conductivity tube incorporates an exit restriction (8) to extend solution residence time under conditions of low flow.

15   The size of this restriction is a compromise between extended residence time and the ability to pass dense or solid components in the solution flow without blockage. The conductivity tube also receives preferential supply from the accumulation chamber to extend performance under low flow

20   conditions. The preferential supply is due to the lower position of its entry orifice (4) compared to entry orifice (5) of the alternative solution passageway through a bi-pass tube (7).

The bi-pass tube (7) carries overflow solution from the accumulation chamber mixed with the separated air stream from the entry chamber. The tube dimensions including the entry (5) and exit (9) orifices ensure that the over-all manifold causes minimal head loss.

In a preferred embodiment of the present invention the bi-pass tube is fitted with electrodes and used to measure fluid mass within the tube. This can be used to determine mass-flow and volume from the time dependency of the measured mass. Here the tube requires a low length to sectional area ratio and a co-ordinated external electrode configuration (13) to enhance dielectric effects associated with fluid mass and reduce conductivity effects. In one embodiment of the present invention useful performance was achieved with a plastic tube of about length 100 mm, diameter 15 mm, and wall thickness 0.9 mm and asymmetric electrodes of about 25 mm and 73 mm length encircling each end of the tube. The asymmetric nature of the electrodes provides for the detection of the fluid velocity since it sometimes arrives in large "plugs" in sympathy with the pulsation of the milking machine. The "plug" first moves past the smaller electrode and then causes a time dependent ramp in mass measurement as it moves past the large electrode. The known electrode length divided by the ramp time gives

velocity. Filtering over many "plugs" is needed to get practical results with minimum uncertainty.

An exit chamber (10) collects the outflow from both the
5 conductivity tube and bi-pass tubes. The solution exits the manifold through an exit pipe (11)

One possible physical implementation of a manifold arrangement is illustrated in Figure 2. Other arrangements are possible.
10 It will be seen in Figure 2a that entry pipe 1 is tangential to entry chamber 2 to produce the "whirlpool" effect.

Of relevance to the third and fourth aspects is conductivity sensing and signal conditioning circuitry that can operate in
15 conjunction with the manifold and attached electrodes described herein or with some other arrangement.

Figures 3 and 4 show the signal sensing block diagram and phasor addition method used to improve the conductivity
20 measurement.

The sensing system is driven by an oscillator (50) producing a high frequency sine-wave excitation voltage (51). The oscillator frequency needs to be selected for a particular

fluid tube and electrode arrangement. In one embodiment of the

present invention the manifold described herein a frequency of

about 6 MHz was high enough to give a satisfactory

performance. The excitation voltage (51) is fed to a circuit

5   section performing conductivity measurement (52-60) and in a

preferred embodiment of the present invention a circuit

section performing mass measurement (61-69).

The excitation voltage is impressed across a conductivity

10   sensor assembly (52) by a coupling circuit (53). The sensor

assembly represents a load that can be considered as a fixed

capacitance due to the tube wall in series with a parallel

combination of fixed capacitance due to the solution

dielectric and a variable resistance (conductance) due to ion

15   solutes in the solution. However, because of the physical

design of the conductivity tube and electrode assembly

described herein, the capacitance due to the solution can be

neglected and the load simplified to a fixed capacitance and

variable resistance series circuit.

20

The current in this capacitance-resistance series circuit is

shown in the phasor diagram of Figure 4(a). The reference

phasor is the excitation voltage (101). The circuit current

leads this voltage with a phase angle that depends on the

variable resistance component. At high resistance (low ion
concentration) the current is small and has a small phase lead
(102). At a standard resistance (typical ion concentration)
the current is moderate with a phase lead of about 45 degrees
5   (103). At low resistance (high ion concentration) the current
is large and with a phase lead approaching 90 degrees (104).
With the ion concentration range found in healthy to mastitis
infected cows the practical variation in phase is rather less
than the 0 to 90 degree limit points above. In addition, the
10   current amplitude is small for practical excitation voltage
amplitudes and therefore sensitive to interference from
electrical noise. The current does however represent
conductivity as phase shift which is the fundamental
conductivity sensor output (54) (Figure 3).

15

In order to improve both the range of phase shift and
amplitude of the conductivity sensor, a second development
current is employed. This is derived from the excitation
voltage (51) using a development current circuit (55). The
20   circuit is designed to produce a current that is equal in
magnitude but opposite in phase to the imaginary component of
the sensor current output at a standard ion concentration. The
development current output (56) and conductivity sensor

current output (54) are summed (57) to give the improved
performance.

The phasor diagrams in Figure 4(a) and (b) illustrate the
5   effect of employing the development current. The development
current as designed lags the excitation voltage (101) by -90
degrees (105). When added to the sensor current the resulting
output amplitude is maintained a moderate level and the phase
shift range is doubled. At high resistance (low ion
10 concentration) the current is moderate with a lag approaching
-90 degrees (107). At a standard resistance (typical ion
concentration) the current is moderate and about the same
phase as the excitation voltage (108). At low resistance (high
ion concentration) the current is moderate with a lead
15 approaching 90 degrees (109).

The sensor and development current summer (57) also converts
the current to an ac coupled output voltage (58). This is fed
to a phase detector circuit (59) to give an unfiltered
20 conductivity measurement output (60).

In one embodiment of the present invention the excitation
voltage coupling, current phase-shift response, development
current summation and ac coupled output are performed by a

compact circuit segment shown in Figure 5. A 1:1 high
frequency transformer (121 to 123) shown in the equivalent
circuit form of an ideal transformer (121,122) and magnetising
inductance (23) is used to couple the excitation voltage (51)

5   to the sensor arrangement (52). The sensor response current
flows in the transformer secondary (121) and is reflected in
the transformer primary (122). The development current flows
in the magnetising inductance of the transformer (123). In a
real transformer the primary and magnetising inductance are

10 one, and the response and development currents are summed
intrinsically. A resistor (126) is used to convert the
resulting current (125) to a voltage which is ac coupled using
a coupling capacitor (127) to provide the required output
voltage (58). The use of a transformer as a coupling device

15 also provides a large common-mode impedance caused only by
transformer inter-winding and stray capacitance (124). This
reduces spurious behaviour due to stray fields coupling into
the sensor fluid and surrounding environment. For one
implementation of the sensor arrangement discussed herein the

20 transformer was designed with a magnetising inductance of
about 50 uH.

In a preferred embodiment of the present invention the
excitation voltage (51) is also impressed across a bi-pass

tube and sensor assembly (61) by a coupling circuit (62). The sensor assembly represents a load that can be considered a capacitor in series with a parallel combination of capacitor and resistor as for the conductivity sensor. However in this

5   case, because of the physical design of the bi-pass tube and electrode assembly already explained, the resistance due to the solution is small and the load can be simplified to a fixed capacitance and variable capacitance series circuit.

10 The current in this capacitance-capacitance series circuit leads the excitation voltage by 90 degrees and has an amplitude that depends on the solution mass within the bi-pass tube. The current has zero amplitude for an empty tube and reaches a maximum when the tube is completely full. The

15 current amplitude when the tube is full is relatively small for practical excitation voltage amplitudes and becomes increasingly sensitive to interference from electrical noise as the tube empties. The current does however represent mass as amplitude which is the fundamental mass sensor output (63)

20 (Figure 3).

To prevent interference from electrical noise an offset current is used. The offset current is derived from the excitation voltage (51) using an offset current circuit (64).

The circuit is designed to produce a constant amplitude current in phase with the sensor current output. The offset current (65) and mass sensor current (63) are summed (66) so that an empty bi-pass tube gives a minimum current equal to

5   the offset current.

The mass sensor and offset current summer (66) also converts the current to an ac coupled output voltage (67). This is fed to an amplitude detector circuit (68) to give an unfiltered

10   mass measurement (69). Mass flow is determined from the time dependence of mass within the sensor tube.

In one embodiment of the present invention the excitation voltage coupling, current amplitude response, offset current

15   summation and ac coupled output are performed by the same compact circuit as with the conductivity measurement in Figure 5 but with the inclusion of a capacitor across the coupling transformer primary. This capacitor is selected to cancel the effect of the magnetising inductance current and provide in

20   addition the required off set current.

In one embodiment of the present invention the phase detector (59) and amplitude detector (68) are as set out in Figure 5. The approach used gives an accurate and cost effective

solution to detecting the phase and amplitude of the high
frequency sine-wave signals.

The phase detector compares a zero phase reference output (72)

5   to the improved conductivity output (68). The reference output
is used to give a phase reference that tracks the improved
conductivity output. The reference output is derived from the
excitation voltage (51) using a reference current circuit
(70). The output from the reference current circuit (71) is

10   fed to a current to voltage converter with an ac coupled
output (72) to give the required zero phase reference (73). In
one embodiment of the present invention the zero phase
reference output is obtained using a resistance-capacitance
phase shift circuit and an ac coupling capacitor.

15

Subsequent signal conditioning for the zero phase output (72)
and the improved conductivity output (68) is through identical
pathways to ensure the relative phase relationships are
accurately maintained. A precision squaring circuit is formed

20   by the dc restoration circuit (74), high-speed comparator (75)
and 50% duty cycle integrator (76). The squaring circuit
operates as a feedback regulator for the dc restoration level
that produces a square-wave output with a precise 50% duty
cycle. Squared-up forms of the two input waveforms (56 and 54)

are fed into a high-speed digital phase comparator (80) to
give the unfiltered conductivity measurement (6).

The amplitude detector also utilises a precision squaring

5   circuit. This is formed by the dc restoration circuit (81)
high-speed comparator (82), duty cycle reference (83), and
programmable duty cycle integrator (84). Again the squaring
circuit operates as a feedback regulator for the dc
restoration level but in this case produces a rectangular-wave

10   output with a duty cycle equal to the duty cycle reference
(83) which is set for a low value. When the amplitude of the
mass sensor output (67) is small the output of the integrator
will produce a dc value slightly less than the switching
threshold of the high-speed comparator to maintain a low duty

15   cycle. When the amplitude of the mass sensor output (67) is
large the output of the integrator will produce a dc value
significantly less than the switching threshold of the high-
speed comparator to maintain the same low duty cycle. In this
way the dc restoration level represents amplitude and is the

20   unfiltered mass measurement (69).

Of relevance to the third and fourth aspects is the use of
information in the determination of stock and plant

performance during a normal milking session. Figure 7 shows
the information flow.

Multiple measurements of predetermined parameters are made by

5   multiple units (150) during the milking process and made

available over a communications network (152). The measurement

information from the communications network is collected and

used to incrementally construct statistical profiles for each

predetermined parameter (152) and at the end of the milking

10   process the set of profiles is saved for later use (154). At

some stage near the start of the milking process a

determination is made as to which of the stored set of

profiles best matches the current milking situation (155). The

best match set together with user or pre-determined standards

15   of performance (156) and the current incremental profiles

(152) are used to calculate performance assessment criteria

(157). These are made available on a communications network or

used locally. The assessment criteria are used to determining

performance by comparison with measurements during the milking

20   (158).

The use of best match profiles allows performance to be

monitored and assessed relative to the norms of a particular

herd and plant. Performance determined in this way is of the

most practical value as farm management is performed within

parameters determined by local conditions. It allows

performance to track with local variation such as farm

location, changes in feed, and stage of lactation. This

5   prevents excessive alerts from absolute measurement not

relevant to the local situation. In addition, the selection of

best match profiles including frequency of occurrence

distributions allows for management with performance standards

defined by a number of stock. A standard of this kind can be

10   used with the best match profile distribution to calculate

performance criteria for measurements to separate out the

desired number of stock. This is in sympathy with on farm

management practices and rather more useful than management

based on an absolute thresholds.

15

In one embodiment of the present invention a Bail Unit is used

for making measurements (151). The Bail Unit incorporates a

microcontroller for signal processing of measurements,

operation of local interface outputs and communication over a

20   common power bus.

Signal processing combines conductivity and mass measurements

with additional measurements of solution temperature, ambient

temperature and time. Processing includes range and mean

filtering to remove noise and improve accuracy, linearisation and scaling to give corrected values, and time and frequency domain analysis to determine rates and periodicity. Known heat transfer models can be used to relate temperature information

5   to mixed air and solution to provide an alternative mass-flow estimation.

The information from the low level measurements and result from signal processing are used to define application level

10 measurements of flow rate, flow periodicity, flow temperature, accumulated volume, conductivity, cycle state (start, mid, end), and cycle type (milking or cleaning).

The application level measurements are compared with

15 calculated performance criteria (157) to determine stock and plant performance. Stock performance includes indicators of milk with mastitis, milk flow, milk volume yield and end of milking. Plant performance includes abnormal bail equipment characteristics including milking time, air solution ratio,

20 pulsator rate. Abnormal cleaning characteristics include correct hot or cold cycles, cleaning phases (rinse, wash) cleaning volume, cleaning temperature and detergent use.

In one embodiment of the present invention performance
criteria and measurements are compared in the Bail Unit and
indicated through a local interface. One arrangement includes
a display with lights (LED's) for performance level and
5   parameter type and an audible sounder and relay output for an
unsatisfactory performance alert. Alerts include mastitis (SCC
alert), low yield (Yield alert), abnormal bail equipment
(Plant alert) and abnormal cleaning (Clean alert). Application
level parameters are also indicated through the local
10   interface. These include current milk flow and yield and end
of milking.

In one embodiment of the present invention the communications
network (151) is provided for using modems on a power
15   distribution bus. Connected to the same bus is a Command Unit.
In the Command Unit measurements are collected and parameter
profiles built (152), sets of profiles stored (152), settings
for user and pre-determined standard of performance are
provided (158) and performance assessment criteria are
20   calculated.

In one arrangement sets of profiles are stored for two
previous milkings (normally the previous morning and evening).
The best match profile set is that which corresponds to the

current milking based on an elapsed time of about 24 hours.
User input is set through a function (parameter type) and
threshold (standard of performance) switch stored in the
Command Unit with a save switch. Lights (LED's) are used to

5   give an indication of the current settings. Functions can be
disabled by special threshold values.

The sensor technology described herein provides for a
sufficiently accurate measurement of milk conductivity under

10   the conditions of low flow milk mixed with air to be of
practical use in detecting mastitis. It is possible to make
accurate conductivity measurements because of the sensor
manifold design that provides at least partial separation of
milk and air and a conductivity tube geometry with co-

15   ordinated electrode arrangement for sensing through the tube
wall that is sensitive to conductivity. Measurements are
further improved by signal conditioning that uses a phasor
addition method to cancel unwanted effects caused by sensing
through the tube wall. This increases output range and noise

20   immunity. The sensor manifold, electrode arrangement and
signal conditioning circuits form a simple, reliable, and low
cost sensor with no moving parts, no electrodes in solution,
no hygiene traps and minimal head loss.

Placement in the top of the long milking tube provides
protection from the harsh milking environment and enables
automatic measurements. Preferred arrangements include
additional sensing and signal processing that provides for
5   additional measurements of stock and plant performance.

Implementation using multiple Bail Units communicating over a
network to a single Command Unit allows for profiles of
measurement parameters to be constructed and stored.
10   This enables standards of performance to be defined in terms
of on farm stock and plant norms using levels or number of
stock in contrast to other systems that enforce absolute
standards. Using standards within an on farm context is in
keeping with farm management as is actually practised.
15

The Bail Unit and Command Unit implementation provides an
effective low cost solution well suited to the practical farm
environment. The basic system can be extended for other dairy
automation requirements including remote display, cow
20   identification and counting, automatic cluster removal,
supplement feeding and automatic cow drafting.

A preferred communications interface on the Command Unit
together with support software enables remote access using

standard telecommunications infrastructures including the internet to provide farm or industry based computer systems and services.

5   Where in the foregoing description reference has been made to integers or components having known equivalents then such equivalents are herein incorporated as if individually set forth.

10   Although this invention has been described by way of example it is to be appreciated that improvements and/or modifications may be made thereto without departing from the scope or spirit of the present invention.

CLAIMS

1. A method for conductivity measurement comprising the steps
of:

5   dividing a fluid or mixed gas and fluid flow between a
first and second flow path;

       causing the fluid to flow preferentially within the first
path having a relatively long and narrow form;

       measuring a parameter determined by the fluid in the path
10   having a relatively long and narrow form;

       determining the conductivity of the fluid based upon the
measured parameter.

2. The method according to claim 1 wherein gas is at least
15   partly separated from fluid to aid the preferential flow of
fluid to the first flow path.

3. The method according to claims 1 and 2 wherein gas is at
least partly separated from fluid to aid the preferential flow
20   of fluid to the first flow path by the introduction of a
swirling action.

4. The method according to any one of the preceding claims
wherein gas is at least partly separated from fluid to aid the

preferential flow of fluid to the first flow path by use of a
surge or settling chamber type action.

5. The method according to any one of the preceding claims
wherein fluid to the first flow path is accumulated to sustain
a more continuous flow.

6. The method according to any one of the preceding claims
wherein fluid flow from the first flow path is restricted to
increase residence time or time for continuous flow.

7. The method according to any one of the preceding claims
wherein fluid volume in the first flow path is minimised to
increase residence time or time for continuous flow.

8. The method according to any one of the preceding claims
wherein the first flow path is fitted with additional sensors
for measuring parameters determined by the fluid.

9. The method according to any one of the preceding claims
wherein the second flow path is used to bi-pass fluid or gas
an fluid mix not able to be accommodated by the first flow
path.

10. The method according to claim 9 wherein the second flow path is used to bi-pass fluid or gas and fluid mix not able to be accommodated by the first flow path with dimensions that reduce pressure or vacuum head loss.

5

11. The method according to any one of the preceding claims wherein the second flow path is used to bi-pass fluid or gas and fluid mix not able to be accommodated by the first flow path is fitted with sensors to measure a parameter determined

10   by the fluid or gas and fluid mix.

12. A conductivity measurement apparatus comprising:

a manifold including a first and second flow path for conveying a fluid or mixed gas and fluid flow, causing the

15   fluid to flow preferentially within the first path of relatively long and narrow form;

a sensor provided for the first path for measuring a parameter determined by the fluid;

a conductivity determining circuit which determines the

20   conductivity of the fluid based upon the parameter measured by the sensor.

13. The apparatus according to claim 12 wherein a manifold that employs a method according to claims 1 to 11 is used.

14. The apparatus according to claim 12 wherein a sensor constructed from electrodes distributed along the length of the first path and at least partly surrounding the fluid

5 either on the inside or outside of any containment walls is used.

15. The apparatus according to claims 12 to 14 wherein high frequency electric fields are coupled to the sensor

10 electrodes.

16. The apparatus according to claims 12 to 15 wherein current or voltage phase or amplitude response is used to determine conductivity.

15

17. A method for measurement of conductivity comprising the steps of:

measuring a parameter determined by a fluid by sensing through a containment wall made of electrically insulating

20 material;

improving the measurement sensitivity by at least partially cancelling the effect of the dielectric properties of the containment wall;

providing an output representing the conductive component of the measurement.

18 The method according to claim 17 wherein the parameter to
5   be measured is influenced by solutes or solvents that give
rise to conductive properties.

19. The method according to any one of claims 17-18 where the
fluid concerned is constrained to a relatively long and narrow
10 form within a containment wall made of electrically insulating
material.

20. The method according to any one of claims 17-19 wherein a
sensor is constructed from electrodes distributed along the
15 length of the constrained form at least partly surrounding the
fluid outside the containment walls.

21. The method according to any one of claims 17-20 wherein a
high frequency voltage waveform is coupled to the sensor
20 electrodes.

22. The method according to any one of claims 17-21 wherein a
current phase or amplitude response is used to determine a
measurement.

23. The method according to any one of claims 17-22 wherein the phasor addition of another signal cancels out at least part of the response due to the capacitance effect from the containment wall dielectric.

24. The method according to any one of claims 17-22 wherein a phase detector or amplitude detector is used to produce an output representation of conductivity.

25. The method according to any one of claims 17-23 wherein a phase detector or amplitude detector is used to produce an output representation of conductivity.

26. The method according to claim 21 or 22 wherein voltage is used in place of current and current is used in place of voltage.

27 An apparatus for measuring conductivity comprising:

a sensor arrangement for measuring a parameter determined by a fluid through containment walls made of an electrically insulating material;

a signal conditioning circuit that converts the measured parameter into an electrical form;

a signal conditioning circuit that improves the

measurement sensitivity by at least partially cancelling the

undesirable effect of the dielectric properties of the

containment wall;

5   a signalling conditioning circuit that provides an output

that represents conductivity.

28. The apparatus according to claim 27 wherein a method

according to claims 17 to 26 is used.

10

29. The apparatus according to any one of claims 27-28 wherein

an electrode coupling device with high common mode impedance

is used in order to reduce effects of stray capacitance to the

fluid and surrounding environment.

15

30. The apparatus according to any one of claims 27-29 wherein

methods are realised within single components.

31. The apparatus according to any one of claims 27-30 wherein

20   phase or amplitude detection involves converting current or

voltage waveforms into square or rectangular waveforms with

certain timing precision.

32. The apparatus according to claim 31 wherein conversion to square or rectangular waveforms involves a comparator with a feedback loop acting on the duty cycle of the comparator output to adjust the comparator input.

5

33. A method for determining dairy stock and plant performance comprising the steps of:

    making performance measurements during a normal milking session;

10   collecting measurements to incrementally develop performance profiles during a normal milking session;

    storing performance profiles as a completed set at the end of a normal milking session;

    a best fit matching of a stored set to the current

15 milking;

    providing settings for user or pre-determined standards of performance;

    performance assessment for measurements during the current milking session using assessment criteria that are in

20 part determined by stored profiles.

34. The method according to claim 33 wherein measurements are made automatically during the milking session.

35. The method according to any one of claims 33-34 wherein measurements are made for individual cows with or without retaining individual cow identification information.

5   36. The method according to any one of claims 33-35 wherein measurements are made or derived that represent stock performance including milk flow, milk volume, milk yield and milk conductivity.

10   37. The method according to any one of claims 33-36 wherein measurements are made or derived that represent plant performance including pulsing action, milking time, air or fluid flow rates or ratios.

15   38. The method according to any one of claims 33-37 wherein measurements are made or derived that represent cleaning performance including hot and cold cycles, fluid volume, time and detergent use.

20   39. The method according to any one of claims 33-38 wherein performance profiles include distributions, averages, maximums, minimums for individual cows or parts or all of a herd.

40. The method according to any one of claims 33-39 wherein stored performance characteristics for stock can be representative of standards defining a number of cows or a level within the herd.

5

41. The method according to any one of claims 33-40 wherein stored characteristics are matched on the basis of the last diurnal milking period corresponding to the current milking.

10   42. The method according to any one of claims 33-41 wherein performance during the current milking can be categorised as satisfactory or unsatisfactory or represented as a relative value.

15   43. The method according to any one of claims 33-42 wherein measurements result in local annunciation.

44.   The method according to any one of claims 33-43 wherein measurements are used to determine end of milking or cluster

20   removal for individual cows.

45.   The method according to any one of claims 33-44 wherein individual cow identification system is incorporated.

46. The method according to any one of claims 33-45 wherein remote access is incorporated including access to a farm computer system, industry computer system or the internet.

5   47. An apparatus for determining dairy stock and plant performance comprising:

a unit for making measurements during a normal milking session;

a unit for collecting and developing measurement
10 profiles, storing completed sets of profiles, matching stored profiles to the current milking and calculating performance criteria to be compared with measurements during the current milking session from standards of performance;

a unit for annunciation of performance during the current
15 milking session;

a network for communicating information between units.

48. The apparatus according to claim 47 wherein a method in claims 33 to 46 is used.

20

49. The apparatus according to claim 47 or claim 48 wherein measurements are made with a unit at each milking cluster.

50. The apparatus according to any one of claims 47-49 wherein
measurements are made at each milking cluster in-line with the
long milk hose from the milking cluster or the equivalent.

5 51. The apparatus according to any one of claims 47-50 wherein
a commercial computer with appropriate adaptations and
software or dedicated device with in-built computing
capability is used for the unit collecting and developing
measurements to define and store performance profiles and
10 determining performance standards for the current milking
session.

52. The apparatus according to any one of claims 47-51 wherein
the unit for annunciation is also used to input user selected
15 standards or to announce performance for the current milking
session.

53. The apparatus according to any one of claims 47-52 wherein
some or all of the units perform their functions
20 automatically.
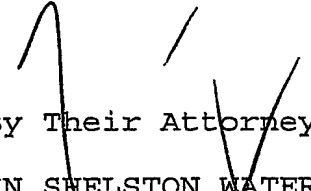
54. The apparatus according to any one of claims 47-53 wherein
announcement of performance for the current milking session is

made with a unit at the milking cluster position as part of
the measuring unit or a separate unit.

55. The apparatus according to any one of claims 47-54 wherein

5 communication between units is performed using a standard
telecommunication network system or a dedicated network
(including a power line modem.

10   RADIAN TECHNOLOGY
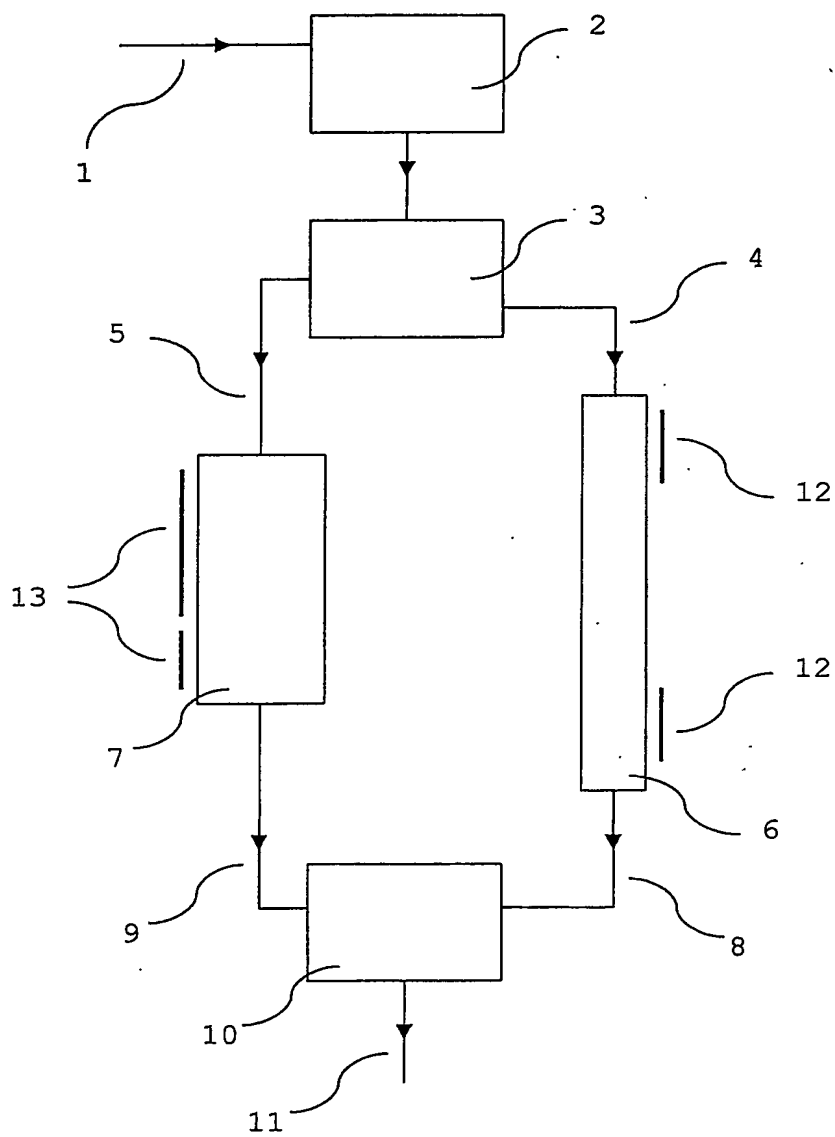
                                           By Their Attorneys
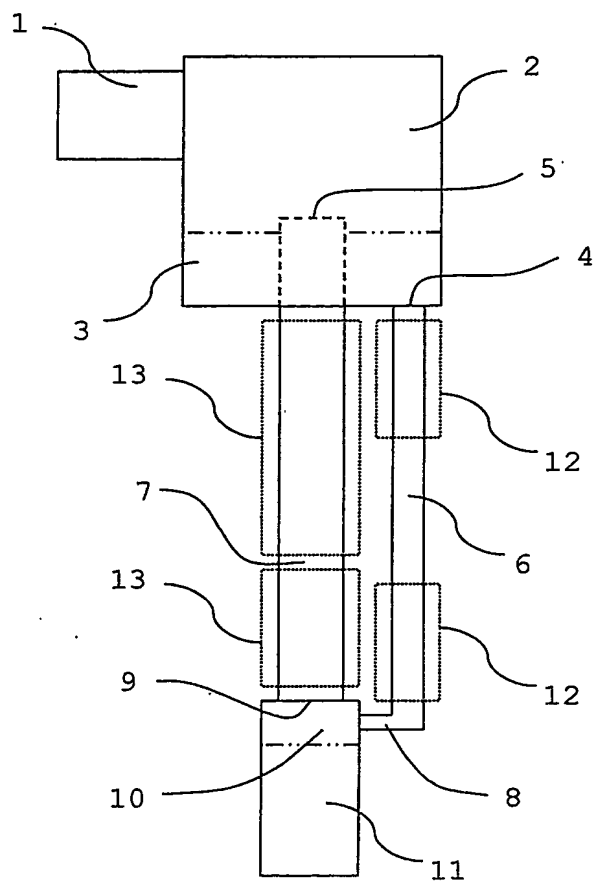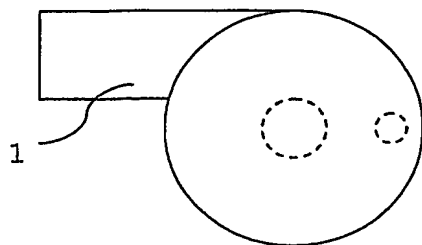   BALDWIN SHELSTON WATERS

Figure 1: Manifold flow schematic

Figure 2a

Figure 2: A manifold implementation
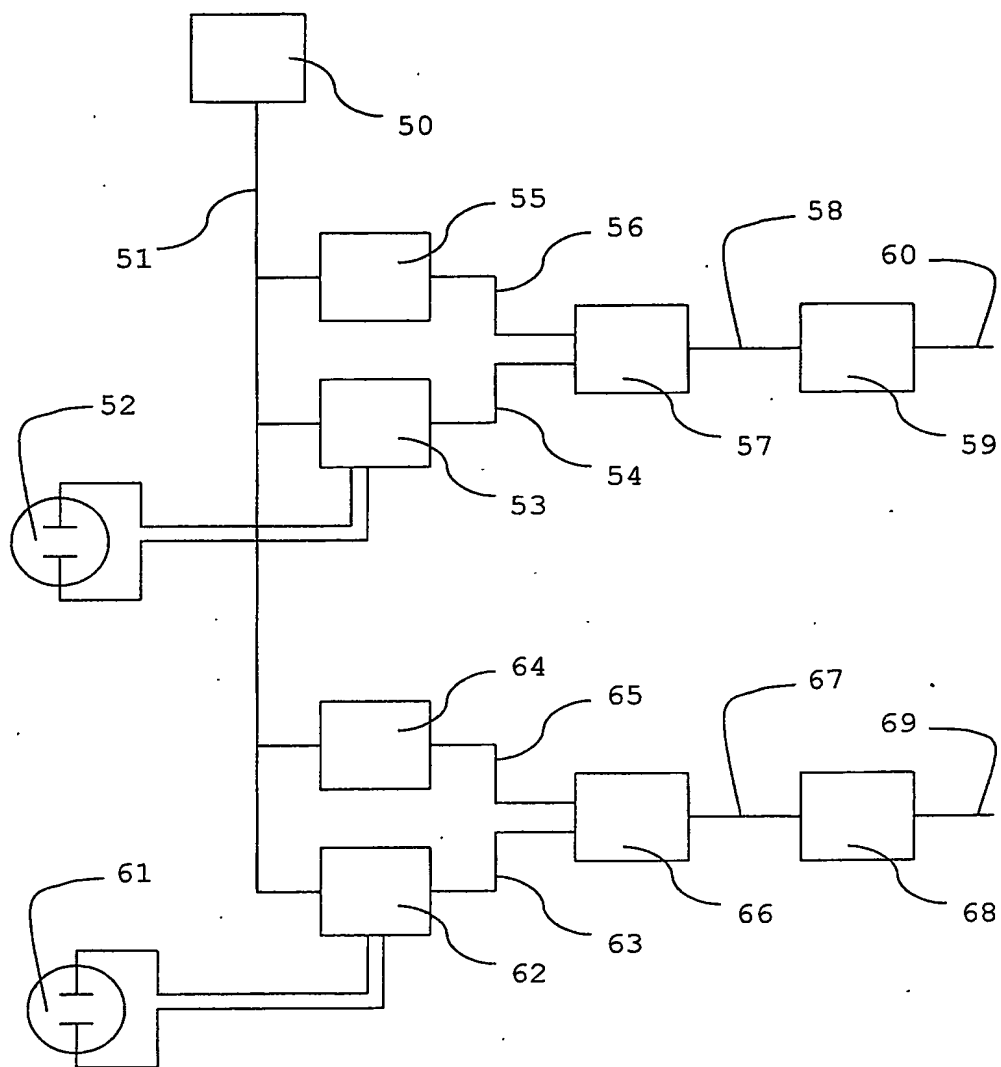
Figure 3: Sensing system schematic
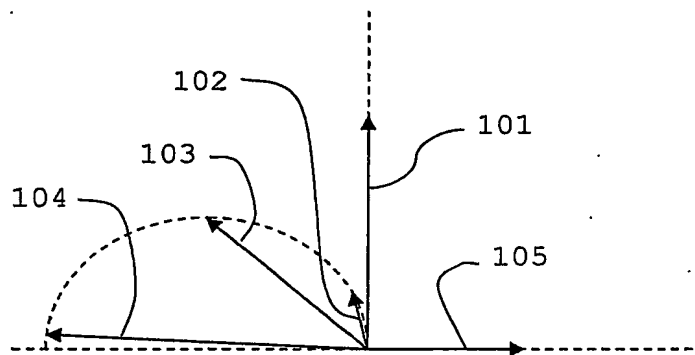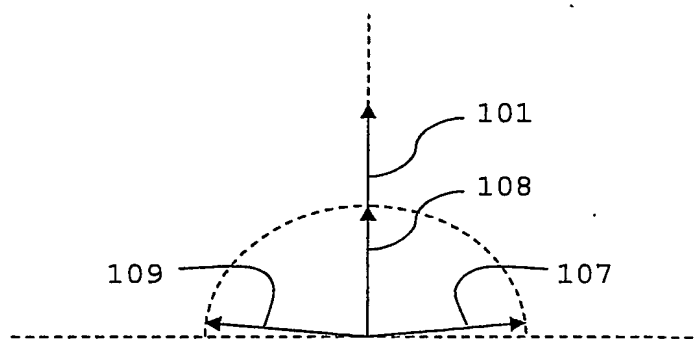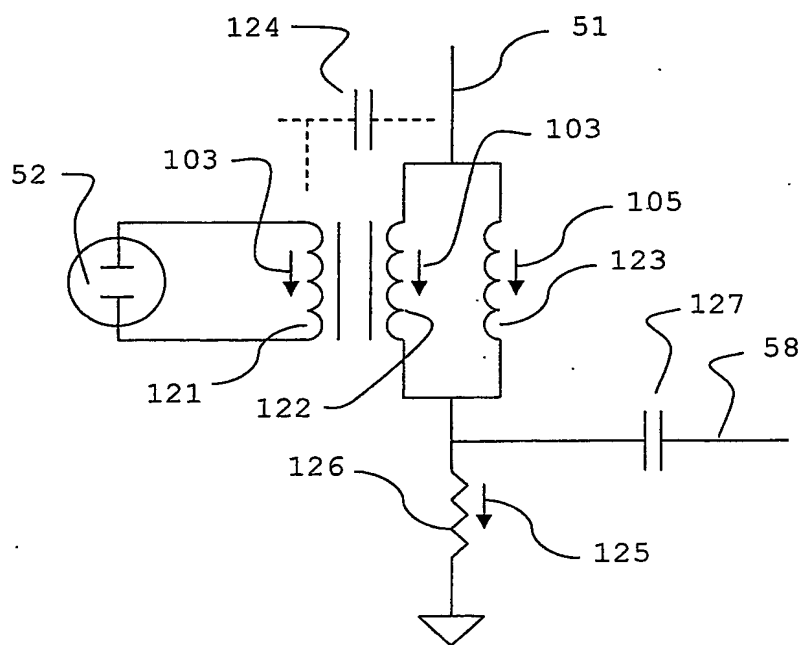
Figure 4: Development with phasor addition

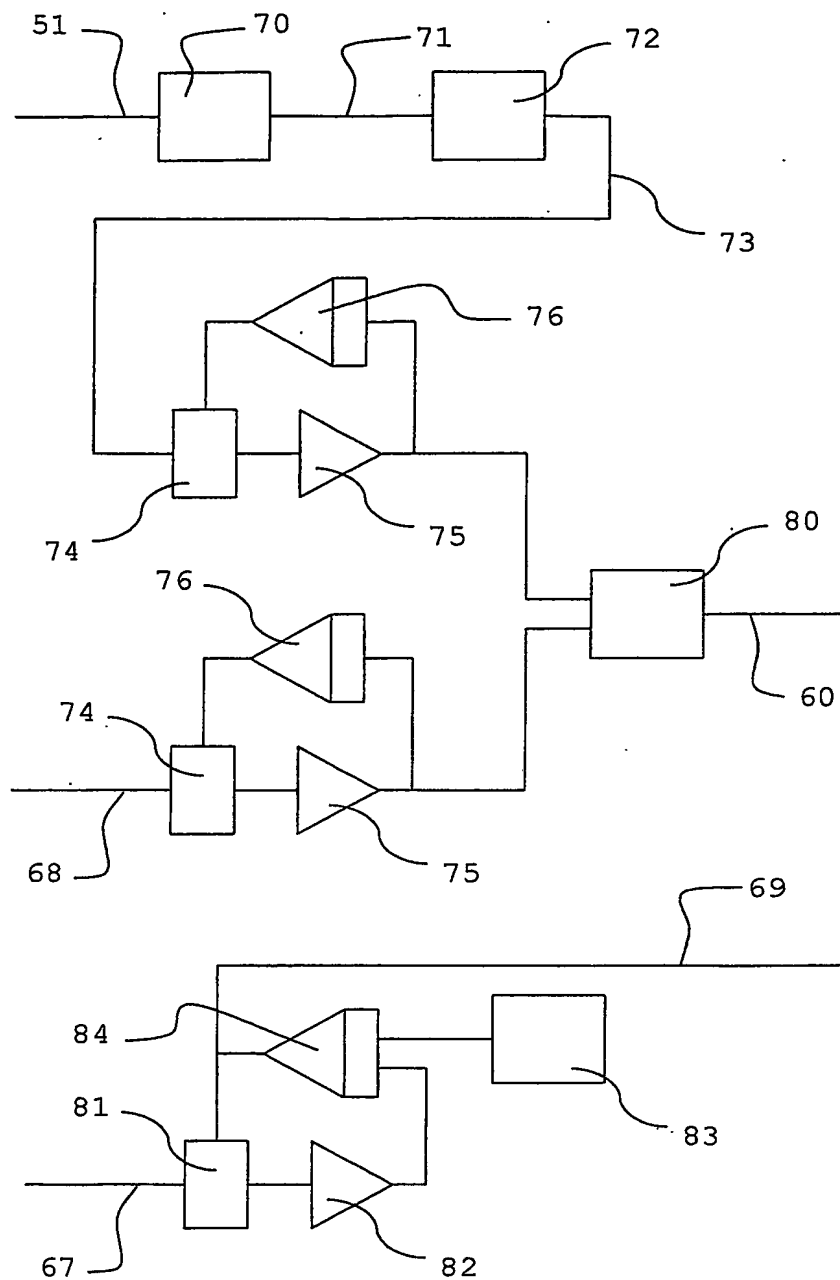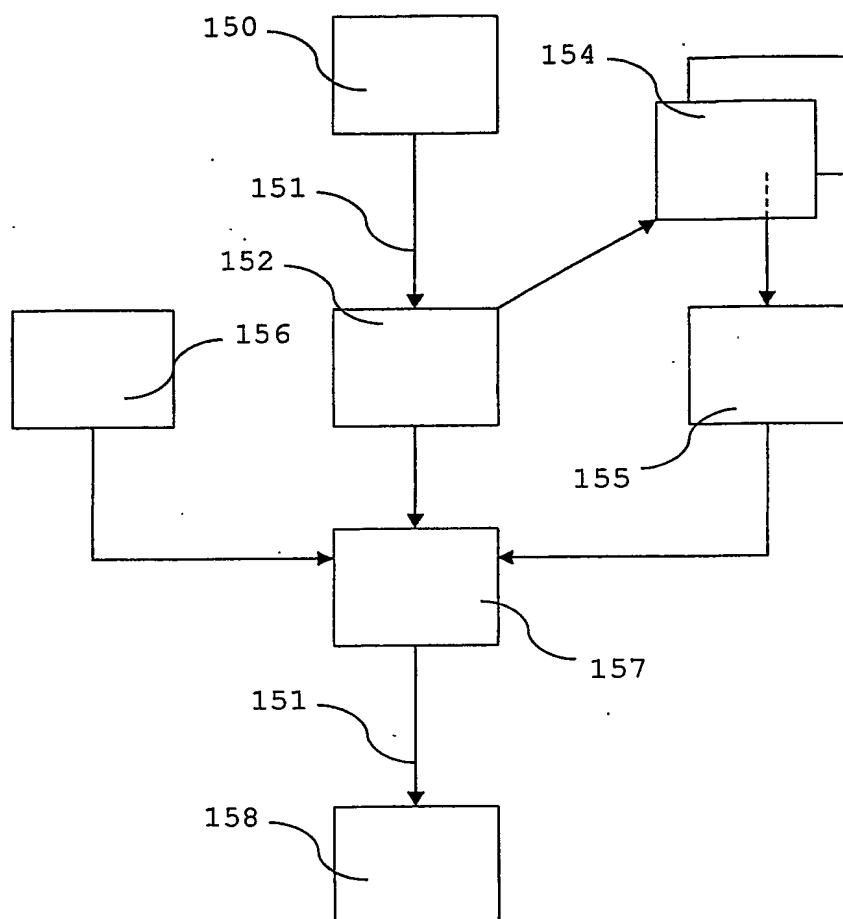Figure 5: A particular sensor circuit

Figure 6: A signal conditioning schematic

Figure 7: Performance information flow